Acta Mineralogica—Petrographica, Szeged, XXIII/2, 279—297, 1978

THE SARMATIAN FORMATIONS IN THE TISZÁNTÚL AREA [EAST HUNGARY] AND THEIR STRATIGRAPHIC POSITION

K. SZENTGYÖRGYI

ABSTRACT

In the hydrocarbon prospecting area of Tiszántul Upper Miocene formations have been hit by more than houndred bores. The sediments of the Sarmatian stage correspond to the time interval between the Badenian and Pannonian ages. The stage is biostratigraphically bipartite (Kozardian and Tinnyean substages). In the Tiszántúl area the Sarmatian formations are overlying the Badenian rocks, transgressively near the shore and comformably in the inferior of the basin. They are overlain, on their turn, by different lithostratigraphic members of Pannonian stage. There is a stratigraphic gap of varying importance and at some places a slight angular unconformity to be observed between the Sarmatian and Pannonian stages.

The transgressive basal beds of the Kozardian substage are usually overlain by littoral Miliolina limestone. The brackish water Kozardian sediments pass gradually, without any trace of interrupted sedimentation, into the mostly carbonatic sequence of the Tinnyean substage. The formations of this younger substage, however, are missing in the major part of the area, due to erosion, or they are known in some isolated occurrences only.

The sediments of the Sarmatian stage are characterized by a brackish water microfauna consisting of a few taxons represented by numerous specimens. Towards the end of Kozardian substage about the half of the forams have become extinct.

The Upper Miocene sediments explored in the Tiszántul area have been deposited in a shallow-water basin of rather complicated shore-line. In the northern part of the area and in the Nyirség at the same time the continental sequence of rhyolitic volcanic formations came into being.

The Sarmatian sediments disclosed by hydrocarbon drilling can be correlated biostratigraphically with the sediments of the surrounding basin areas, while the lithostratigraphic units can be traced for short distances only even within the Tiszántul area.

INTRODUCTION

During hydrocarbon exploration Upper Miocene formations were hit in several boreholes of the Hungarian Plain, more exactly, in the Tiszántúl area. The stratigraphic position of these sediments and their relathionship as to the much better known geological profiles of the mountain margins have been scarcely studied so far.

The type section of the Sarmatian stage was originally described by BARBOT DE MARNY, N. in the surroundings of Kherson. The stratigraphically tripartite character of the stage was established by ANDRUSOV, N. [1899]. SIMIONESCU, J. [1903] proposed the denominations of the Volhynian, Bessarabian and Khersonian substages. At present, in the type region (East Europe) the Sarmatian stage is subdivided into three substages (the Volhynian, Bessarabian and Khersonian ones) and six horizons [KOJUMDGIEWA, E. 1971]. In the area of the Central Paratethys (in its presentday sense) SUESS, E. [1866] was the first distinguish Sarmatian sediments in the Neogene sequences of Austria. He ranged into the Sarmatian the "Cerithium Beds" comprised between the "Baden Clay" and the "Congeria Beds".

It soon became evident, that the Sarmatian formations do not represent the same time interval in the Euxine-Caspian Basian and in the Carpathian Basin.

In the latter, only some part of the stage has been developed if compared to the Sarmatian stage as developed in South-Eastern Europe. In another, but not very exact formulation this means that the Sarmatian formations of Eastern and of the Central Paratethys correspond only partly to each other: in large areas of the Central Paratethys a considerable part of the Sarmatian sediments of Southern Russia is represented by the Pannonian sediments.

The difficulties arising in the correlation of the Sarmatian stage are essentially due to the fact, that *during the Bessarabian the intracarpathian basins of the Central Paratethys became isolated from the Eastern Paratethys* and mostly of each other, too.

Relying upon the investigation into the Sarmatian outcrops in Hungary, SCHRÉTER, Z. [1912, 1941] stated that their fauna is identical to that of the Volhynian substage in Southern Ukraina. Even the more recent studies could produce only a few forms characteristic of the Bessarabian substage (BODA, J. 1959]. However, the vertebrate studies suggested that the Sarmatian formations in Hungary should comprise at least some part of the Bessarabian substage [KRETZOI, M., 1961]. Finally it could be established by BODA, J. [1971, 1974] by means of molluscs and by KŐVÁRY, J. [1973] as regards the microfauna that the Sarmatian sequence in Hungary is biostratigraphically bipartite: *the Kozardian substage corresponds to the Volhynian one while the Tinnyean substage to the lower part of the Bessarabian substage* [BODA, J., 1974]. *If speaking about Sarmatian in Hungary, the time interval comprised between the end of the deposition of the Badenian formations and the beginning of the deposition of the Early Pannonian sediments.*

The investigation of the Sarmatian formations in Hungary was not extended, for a long time, to the interior of the basins, due to the fact that they were not disclosed. The better understanding of the geology of the deeper parts of the Great Plain, comprising also the Tiszántúl area, is closely linked up with hydrocarbon prospecting. Between the two World Wars, a few boreholes were drilled financed by the State Treasury. These were improductive from the point of view of oil geology, but they enhanced considerably our knowledge about the deeper part of the Great Plain [SCHMIDT, E. R., 1939]. The first boreholes to hit Sarmatian formations in the Tiszántúl area were Hajdúszoboszló-II., Debrecen-I. and Tisztaberek-1.

After World War II the oil and gas industry having been nationalized, its methods changed and its dimensions were considerably enlarged. Hydrocarbon prospecting became an industrial-scale activity. This lead to the better knowledge of individual areas, notwithstanding the only partial (periodical) core drilling generally used. Rapid development in geophysical well-logging methods contributed undoubtedly to the clearing up of the position of the drilled formations.

During the past three decades, Upper Miocene formations were discovered in 30 prospecting areas of the Tiszántúl. The results of hydrocarbon prospecting in this region were summed up by KŐRÖSSY, L. [1956]. He pointed out that the Sarmatian sediments at some places are overlying unconformably and transgressively the older rocks and established that they represent the Volhynian substage of East Europe. Analyzing the subsurface geological setting of the central part of the Great Plain, VÖLGYI, L. [1965] draw the conclusion that the Lower Pannonian limy marl and the Sarmatian limy marl are synchronous facies, but this assumption was not supported by any biostratigraphic evidence. Even the microbiofacies studies resulted only in producing a possibility of distinguishing the fossil assemblages of the Badenian and the Sarmatian. Neither the foraminifers, nor the ostracods permitted the reliable subdivision of the Sarmatian sediments. Consequently, lacking the help of biostratigraphy, and due to the difficulties of lithostratigraphic subdivision, as concerns the Sarmatian sequence of the Tiszántúl area it could be stated only that theys it represents the older portion of the stage, but the interrelation of the sequences in different parts of the area remained an unsettled problem [SZÉLES, M., 1970, SZEPESHÁZY, K., 1971].

LITHOSTRATIGRAPHY

1. Extent and bedrock

Upper Miocene (Sarmatian) formations are known in several hydrocarbon prospecting areas of the Tiszántúl region, being of the largest extension in the central and northeastern parts *(Fig. 1.)*. Their being hit by a few drillings only causes difficulties in the paleogeographic reconstruction.

The brackish-water Sarmatian sediments overly unconfomably partly Badenian, partly more ancient rocks.

Sarmatian sediments overlying *transgressively* the Lower Paleozoic basement is known at Csanádapáca, Körösszegapáti, Sarkadkeresztúr, Füzesgyarmat as well as south of Nagyvárad (Oradea). The Upper Miocene is underlain by Triassic in the borehole Magyardombegyháza-1, by Jurassic in borehole Hajdúszoboszló-II by Cretaceous in borehole Kunmadaras-8. Along the Senonian-Paleogene flysch trough of the Tiszántúl region the Sarmatian sequence lies upon flysch sediments (borehole Turgony-1, Ebes-7, Hajdúszoboszló-3, Hajdúszoboszló-5, Hajdúszoboszló-17), as well as in the NE prolongation the Flysch belt in the vicinity of Scarisoara Noua and Piscolt. The distribution of the locally transgressive Sarmatian sediments is essentially the same as that of the Badenian ones.

The Badenian sedimentary basin, being rich in islands, was added to by several portions of the dry land, while at other places the Sarmatian sediments lie transgressively. In many cases it is difficult to decide whether the lack of Sarmatian sediments is primary or due to removal at the Miocene-Pliocene boundary. The immediate bedrock is of *Badenian* age in boreholes Csanádalberti-1., Szandaszöllős-10. and one part of the boreholes in the Kisújszállás, Püspökladány, Furta-Zsáka, Nádudvar, Komádi, Kaba, Ebes and Hajdúszoboszló. In the most cases the Sarmatian formations are underlain by Badenian marine deposits in the Nagyvárad—Szatmárnémeti (Oradea-Satu Mare) basin. Rhyolite and rhyodacite tuffs of badenian age overlain by Sarmatian sediments in boreholes of Hajdúnánás, Balmazújváros, Debrecen, Nagyiván and Tatárülés. The stratigraphic subdivision of the mighty neovolcanic sequence in the Tiszántúl region is still an unsolved problem. These series consisting mostly of pyroclastites comprise very likely the combined time interval of the Badenian and Sarmatian ages (at Komoró, Hajdúhadház, Nyírmártonfalva, Hajdúböszörmény, Nagyecsed). At some places the undivided volcanic sequence is overlain by the brackish water sedimente of the Late Sarmatian (Tinnyean) substage. In such cases the volcanic formations correspond to the time interval of the Badenian—Kozardian (e.g. at Nyíregyháza, Nyírlugos, Tisztaberek).

It is rather difficult to draw the contours of dry land in the Sarmatian sedimentary basin. This due to the rather unequal grad of exploration as well as to erosion.

The southern and southeastern margin of the basin can be traced (relying upon the presence of transgressive littoral sediments), the position of the islands, however can not be established, with the exception of the Nyírség volcanic ridges.

The contact of the Badenian and Sarmatian sediments is directly known in a few profiles only. Usually, in cases of continuous core drilling, a gradual transition can be stated. In the Szandaszőlős borehole (Sza-10.) the Badenian-Sarmatian boundary is at a depth of 1812 m. The Upper Badenian is made up by compact, sandy Lithothamnian limestone. This rock contains a rich assemblage of benthic foraminifers *(Asterigerina planorbis* D'ORB., *Anomalina simplex* D'ORB., *Borelis melo* FICHT.—MOLL., *Elphidium crispum* LINNE). This passes gradually into a compact

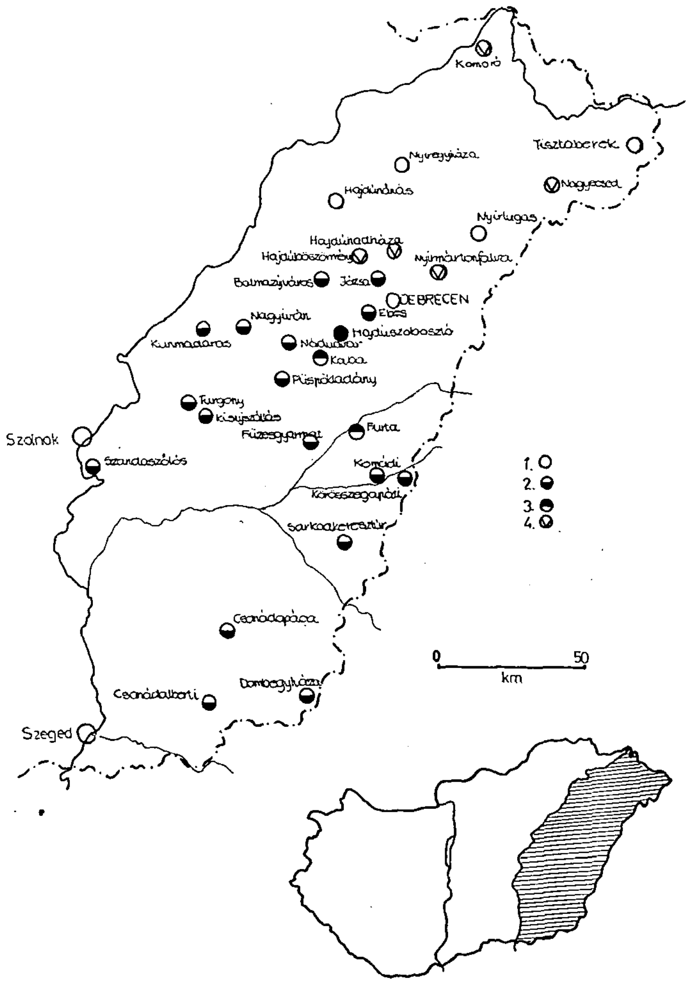

Fig. 1. Occurrences of Sarmatian formations in the Tiszántúl region

Legend

1. The Kozárdian substage is made up by continental volcanites, the Tinnyeian substage by brackish water sediments
2. Brackish water sediments of the Kozardian substage
3. Brackish water sediments of the Tinnyeian substage
4. Sarmatian represented by continental volcanites

Miliolina limestone with thin intercalations of limy marl, assigned to the Kozárdian substage. In the Püspökladány area the gravely *Lithothamnian* and *Amphistegina* bearing limestone of the Badenian passes without interruption into the equally gravely *Miliolina* limestone of the Kozárdian substage (borehole Pü-4.). In this material KŐVÁRY J. found *Cibicides lobatulus* WALK.—JAC., *Triloculina consobrina var. sarmatica* GERKE, *Elphidium macellum* FICHT.—MOLL, *Bolivina sp.* and *bryozoans.* Without any sign of interrupted sedimentation develops the Upper Miocene from the littoral Badenian in the lithologic column of boreholes Józsa-2 and Kisújszállás-1. In the Nádudvar are (borehole Nu-10.) the transition is known to occur in a more off-shore facies. Here, Lower Badenian rhyolite tuff is overlain by *Orbulina* marls, the Upper Badenian being represented by limy marls with *Lithothamnium* nodules. In the lower portion of this marl series marine foraminifers are still common, whereas in the upper one the brackish water *Miliolina* are predominating, accompanied by *Cibicides lobatulus* WALK.—JAC.

Thanks for lucky core sampling, in some boreholes of the Tiszántúl region the presence of Kozárdian beds overlying *transgressively* Badenian sediments could also be established. In borehole Csanádalberti-1 the Badenian silty, plancton foraminifera bearing marls are overlain by limy microconglomerate beds with rounded *Lithothamnium* nodules, incrusted *Pyrgo sp.* and *Miliolina* specimens. This transgressive conglomerate with redeposited Badenian microfossils of 11 m thickness passes into a 43 m mighty Kozárdian conglomerate characterized by the presence of persistent marine foraminifers only *(Anomalina sp., Bolivina sp., Nonion depressulum* WALK.—JAC., *Elphidium antoninum* D'ORB., *Elphidium aculeatum* D'ORB., *Elphidium crispum* LINNE, *Dendritina sp., Cibicides lobatulus* WALK.—JAC.).

The relationship existing between the sediments of the two stages could not be established with certainty in borehole Komádi-8. The sample taken from the depth interval 2008—2020,5 m was an *Orbulina* and *Globigerina* bearing siltite, while the next one upwards (between 1992 and 2000 m) was already a marly siltite with *Articulina* and *Miliolina,* belonging to the older substage of the Sarmatian. The 8 m metres between the to cores reveal no significant change in the lithology according to geophysical well logging, so their belonging to the Upper Badenian can not be ascertained.

At the boundary of the central and the northeastern parts of the Tiszántúl region, volcanic formations are widespread in the sequences. If there are Upper Badenian "Leithakalk" beds intercalated among the tuffs, the Badenian/Sarmatian boundary is easy to trace (boreholes Kaba-É-3, Balmazújváros-1). However, the neovolcanic sequence of the North Tiszántúl could not be subdivided from the stratigraphic point of view so far. It can be assumed that the mostly tuffitic formations may comprise a considerable part, at places eventually the totality of the Sarmatian.

Similar problems exist as to the position and even to the presence of the Sarmatian formations in the area of the deep depressions of the Tiszántúl region (Hódmezővásárhely—Makó graben, Békés-Depression). From the boreholes drilled in these areas, from the interval of over 100 m comprised between the faunistically proved Badenian and Lower Pannonian beds no core has been recovered. As due to the great depths, drilling technological difficulties affect the quality of lithological information rather negatively, deduced from geophysical well logging. In borehole Makó-2 a sample was taken from 4570 m depth. The conglomerate and marl pieces contain *Elphidium crispum* LINNE and fragments of the algal genus *Lithoporella* suggesting the presence of the Sarmatian. No stratigraphic evidence has been produced by the boreholes at Hódmezővásárhely, Hunya and Kondoros, which would permit to draw conclusions as to the presence or absence of the Sarmatian stage. It should not be disregarded, however, that along the margin of these deep depressions at least the Lower Sarmatian is developed in form of littoral sediments, and that according to our present-day knowledge these depressions were subsiding continuously from the beginning of the Badenian age on. It seems to be rather unlikely that during the Sarmatian no sedimentation should have occured.

2. Formations of the Kozárdian substage

The Kozárdian substage is represented by *brackish water sediments* in the southern, southeastern and central parts of the Tiszántúl region and by mostly *volcanic formations* in the northern one *(Fig. 2)*. The brackish water series are seldom more than 50 m thick, while the volcanic formations may be several times thicker. The complete thickness of the sedimentary sequence of the Kozárdian substage is, in fact, reliably known in the surroundings of Hajdúszoboszló only, where it is 40 to 60 m.

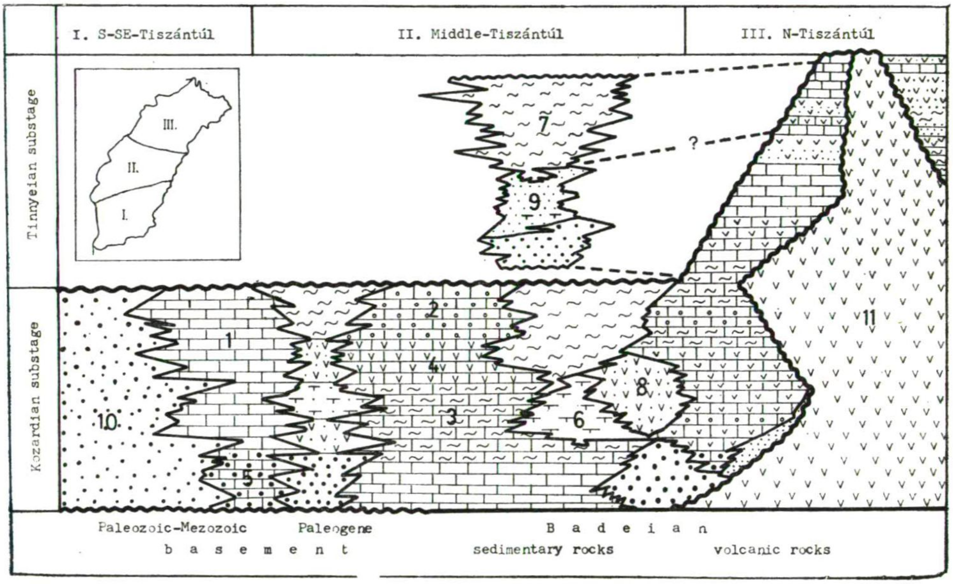

Fig. 2. Interrelations of the lithological units of the Sarmatian in the Tiszántúl region (Strongly distored)

Legend

1. Compact, unstratified limestone
2. Ooidic limestone
3. Marly limestone
4. Tufaceous limestone
5. Gravely limestone
6. Marl, limy marl
7. Clayey marl
8. Tufaceous sandstone, tuffite
9. Limy sandstone
10. Conglomerate
11. Continental volcanite

The sediments of this older substage are mostly of littoral facies. Off-shore formations are rare and of limited extension.

The marginal, *transgressive sequences* of the sedimentary basin consist often exclusively of conglomerates (at Csanádalberti), at some places, however, their are bipartite. The *lower* member is a basal conglomerate and the *upper* one a littoral Miliolina limestone (at Csanádapáca, Magyardombegyháza, Sarkadkeresztur). The third type of the along-shore series is represented by transgressive *Miliolina* limestone (at Körösszegapáti) with thickness data but rarely exceeding 30 m. This is the case in the are disclosed between Arad and Nagyvárad (Oradea) (at Socodor, Salonta, Chisineu Cris).

The sequences intersected in the central part of Tiszántúl area are characterized by a more varied lithology. A mostly detrital and a predominantly carbonatic facies can be distinguished, without being neatly separated (with interfingering).

The clastic sequences consist usually of a lower conglomerate and an upper sandstone member. The uppermost known member is mostly marl or clay marl. A typical profile has been drilled at Füzesgyarmat (borehole Fü-6.). The Upper Miocene sequence overlies with a transgressive basal conglomerate the brecciated surface of the crystalline basement. This conglomerate passes gradually into gravely sandstone and sandstone. The sequence is closed with a brackish water *Miliolina* and *Elphidium* bearing marl member.

In the Püspökladány area the basal conglomerate is substituted by littoral limestone. This *Articulina* and *Miliolina* bearing limestone is overlain by a sandstone member with thin intercalations of conglomerate. The series representing the Kozárdian substage in borehole Kisújszállás-1 consists, in a similar way, of mostly tuffitic sandstone and sandy tuffite, the marl become the predominant lithologic type in the uppermost member only.

The clastic sequences are found relatively rarely in the Tiszántúl area. The lithology of *the early Sarmatian formations is overwhelmingly carbonatic.* However, the purely carbonatic sequences are but rarely homogeneous. Lithostratigraphic correlation is made difficult by the lithologic variations of the limestones as well as by interfingering and intercalation of detrital sediments.

The most part of the Kozárdian limestones are of biogenic origin, they contain masses of *Miliolina* tests. The compactness and the degree of diagenesis is rather variable, all varieties occur from the easily friable sediment to the hard, compact, calcite-veined limestone. The bioclasts are embedded in a micritic matrix of widely varying amount. The limestones contain considerable allotigenic clastic material, gravel, tuff and often clay. Gravely limestone is characteristic first of all of the beds of deeper lithostratigraphic position. This type of rock is particularly common in places where the Kozárdian develops from *Lithothamnian* limestone. In the same areas also the clayey limestone type is common, representing a transition between the littoral limestones and the off-shore pelitic sediments. It is remarkable that sandstone members of large extension have not been found even in the fairly well explored areas. Rock types earlier described as calcarenites turned out to be ooidic limestones or sandy limestones.

A typical lithological variety, which is, however, not exclusively characteristic, of the Kozárdian substage, is the *ooidic facies,* widespread in the areas of Ebes Hajdúszoboszló, Kaba and Nagyiván. The nucleus of the ooids in the regionally scarcely varying ooidic limestones consists usually of volcanic quartz grains or *Miliolina* tests. They are embedded in a clayey, micritic carbonate matrix. The hardness of the rock depends of the amount and eventually of the nature of the embedding material. No system could be establishes as to the occurrence of the ooidic beds in the mostly limestone sequences. The only certainty is that this rock type has been formed in shallow and periodically agitated water.

In the boundary zone of the central and northern parts of the Tiszántúl area the rhyolite tuffs beds became ever thicker and more numerous as going towards the continental eruption centres. Within the carbonate sequences, they interfinger with the brackish water sediments in a zone at present poorly explored. Notwithstanding the relatively low degree of exploration, it seems probable that in this area the Kozardian substage should be represented by *continental pyroclastites.*

A sedimentation differing considerably from that of the other areas of the Tiszántúl region occurred in the depression between Nagyvárad (Oradea) and Szatmárnémeti (Satu Mare) [ISTOCESCU, D.—IONESCU, G., 1968]. There, the early Sarmatian sediments are developed in a thickness of 100 to 300 m. The sequences are characterized by an alternation of sandstones, limestones and conglomerates. The individual lithostratigraphic member can be traced to longer distance. In the surroundings of Szatmárnémeti (Satu Mare) the rhyolite tuffs became more numerous, growing to a continuous, independent member at the Hungarian frontier. Most likely also in this area in interfingering of the brackish water sediments with the rhyolite tuff series can be established.

3. Formations of the Tinnyeian substage

The later Sarmatian formations are completely *missing in the sequences of the South Tiszántúl area.* Some isolated occurrences of the Tinnyeian substage are known from the central part of the Tiszántúl region. Their continuous, regional extension is, however, characteristic of the northern Tiszántúl. Two isolated occurrences of the substage are the boreholes Furta-2 and Kaba-5 in the central part of the Tiszántúl region. In both boreholes, the Tinnyeian formations overlye transgressively the Lithothamnian, gravely limestone, and the limy conglomerate of the Upper Badenian, respectively. A basal conglomerate grades insensibly into a poorly fossiliferous sandstone, overlain by siltite in the Furta—Zsáka borehole and by clay marl in the Kaba borehole.

Mostly carbonatic sediments compose the sequence of the Tinnyeian substage in the Hajdúszoboszló boreholes. Where drilled with core, a continuous lithological transition could be observed (boreholes Hsz-6., -13., -30.). Passing towards the upper members, the percentage of detrital materials is increasing. (Fine sandy intercalations, more frequent appearance of marly limestone beds.) The ooidic limestone beds become ever rarer. If compared to the limestones of the Kozárdian substage, it is an important lithologic difference, that *no Miliolina limestone occurs in the Tinnyeian.* The end of the rock forming importance of Miliolina does not mean, however, that the biogenic factors of sedimentation became completely subordinate. The tests of other foraminifers and the shells of molluscs play a considerable role in the composition of the limestones. The sediments of this substage are more easy to subdivide lithologically and much less diagenetized, than those of the early Sarmatian. Intercalated marls occur more often, but gravely limestones are very rare.

In the northern part of the Tiszántúl region the brackish water *sediments of the Tinnyeian substage lie transgressively* over the rhyolite tuffs formed in in the Kozárdian or Badenian. In the boreholes of Hajdúnánás, Nyíregyháza, Nyírlugos, Debrecen and Tisztaberek rhyolite and rhyodacite tuffs alternate with beds of limy marl, limestone, tuffitic sandstone and tuffite. In this area, the brackish water sediments display an extraordinary lithologic variability. Due to this fact and to the rather low degree of exploration, no lithostratigraphic correlation can be made. The sequences in the northern part of the Tiszántúl region are relatively mighty, exceeding 100 m, in consequence of the intercalated pyroclastic members, while in the other areas, the late Sarmatian brackish water sediment series have thicknesses below 40 m.

It is difficult to judge the completeness of the Tinnyeian sequences, because they are overlain by Pannonian sediments with a considerable stratigraphic hiatus. It is probable that the surface of the Sarmatian has been modelled by erosion. It is difficult to say, however, how much has been removed by erosion. It is an une settled question the later Sarmatian formations are present in the deep Neogen-depressions. At present it is assumed that the entire Upper Miocene is present, without being disclosed, below the mighty Pliocene cover.

4. *The Post-Sarmatian Cover*

The Sarmatian formations of the Tiszántúl region are covered by Lower Pannonian, in some cases by Upper Pannonian sediments of varying thickness. They are of *greatest thickness, and represented by oldest members, in the area of the deep Neogene depressions,* while they are rather thin and young in the northern part of Tiszántúl. In this latter area, the Sarmatian is directly overlain by Upper Pannonian sediments, the Lower Pannonian is completely missing.

The discussion on the stratigraphic subdivision and biostratigraphy of the Pannonian sediments of the basin is still going on. In this paper this discussion should not be outlined. None the less the stratigraphic position of the Pannonian sediments is in close connexion with that of the Upper Miocene formations. SZÉLES, M. [1971] succeeded in establishing that the Pannonian formations of the Hungarian Plain can be considered biostratigraphically complete at most in the area of the deep depressions only. New points of view and unpublished evidence contributing to a lithostratigraphic model seem to support the biostratigraphic subdivisions.

The molluscs found in the cover of the Sarmatian in the Tiszántúl region prove nothing more than the presence of the Lower Pannonian *horizon of Paradacna abichi* R. H., *Congeria banatica* R. H. In most cases, however, the *erosional unconformity* existing between the Upper Miocene and the Pliocene is testified to not as much by the truncated Lower Pannonian series, as by the lack of the Tinnyeian substage. The stratigraphic gap and unconformity are obvious, in a similar way, in most part of the northern Tiszántúl. The nature of the boundary (contact) between the Upper Miocene and the Pliocene is unknown, can be only hypothetically assumed in the case of the deep depressions of the Tiszántúl region.

BIOSTRATIGRAPHY

1. *Character and Elements of the Fauna*

The biostratigraphic subdivision of the Sarmatian formations of the Tiszántúl region, known only from drill core materials, is based entirely on *microbiofacies analysis*. The macrofauna is rare and do not allow statistical studies, it is good for no more than to ascertain the presence of the stage. The Sarmatian sediments are characterized by their being of brackis water facies. At the Late Badenian/Sarmatian boundary, as a consequence of the decrease in salinity of the sea water, the composition of the foraminiferal and molluscan assemblages changed considerably.

While in the marine sediments of Badenian age in the Tiszántúl region 130 species of 50 foraminiferal genera has been found, only *50 species* belonging to *17 genera* could be discovered in the Sarmatian sediments [KŐVÁRY, J., 1973].

At the beginning of the Late Badenian salinity started to decrease in the Central Paratethys sedimentary basin, resulting in the rapid extinction of planctonic foraminifers. During the Late Badenian, the stenohaline bentonic forms became also subordinate. On the contrary, the highly adaptable euryhaline taxa abounded. At the Late Badenian/Sarmatian boundary the microbiofacies consist mostly of brackish water benthic forms, accompanied by a few specimens of persistent stenohaline species.

At the beginning of the Sarmatian a brackish water microfauna consisting of but a few species, but of pullulating specimens, became widespread. Its elements belong to the families *Anomalinidae, Miliolidae, Ophthalmidiidae, Nonionidae* and *Rotalidae.* The genus *Elphidiums* is represented by 14 species, the genus *Quinqueloculina* by 11 species and the genus *Triloculina* by 6 species.

In the borehole columns the core samples taken only at some intervals and being of small amount do not make possible to use the *molluscan faunas* for subdivision. In the case of some specias it seems to be likely that they are restricted, in the Tiszántúl region too, to one or to the other of the substage. However, with regard to the rare and rather accidental occurrence of these species further observations are needed to evaluate their biostratigraphic value. The most molluscs occur in the sediments of both substages, so their presence allows no more than to conclude as to the Sarmatian age of the sediments in question.

From the Sarmatian sediments of the Tiszántúl area SZÉLES, M. has determined the following molluscs:

Lamellibranchiata

Modiolus incrassatus D'ORBIGNY
Musculus sarmaticus GATNEV
Cardium latisulcatum MÜNSTER
Cardium vindobonense PARTSCH
Cardium praefischerianum KOLES.
Cardium subcarpathicum MERKLIN
Cardium plicatofittoni SINZOW
Irus gregarius PARTSCH
Irus vitalinus D'ORBIGNY
Ervilia dissita EICHWALD
Mactra vitaliana eichwaldi LASK.
Donax dentiger EICHWALD
Donax hoernesi LINDBERG
Abra reflexa EICHWALD

Gastropoda

Hydrobia lineata JEKELIUS
Hydrobia ventrosa FRAUENFELD
Hydrobia frauenfeldi M. HOERNES
Calliostoma angulata EICHWALD
Calliostoma papilla EICHWALD
Gibbula hoernesi JEKELIUS
Rissoa inflata sarmatica FRIEDB.

Pirenella picta DEFR.
Pirenella picta mitralis EICHW.
Cerithium rubiginosum EICHWALD
Gyraulus pavlovici BRUSINA

Up to date, 24 species of *ostracods* are known from the Upper Miocene sediments of the Tiszántúl region. SZÉLES, M. [1958, 1959] described a total of 33 species from the Sarmatian of Hungary; most of these have been found in the area of study, too. The ostracods in the sediments of the Badenian stage are subordinate elements of the faunal assemblage. Only a few families occur. Some of the species died out at the Badenian/Sarmatian boundary, but most of them went on living in the Late Miocene as well. The Sarmatian ostracod fauna is of extreme adaptability, most of its species occur also in the pliohaline formations of the Pannonian stage. The stratigraphic value of the Sarmatian ostracod species needs further investigations, because the data vailable at present refer only to one part of the basin and do not derive from a systematic collecting activity. SZÉLES, M. described the following ostracod species from the formations in the area of study:

Ostracods

Cytheridea punctillata BRADY
Cytheridea elongata BRADY
Cytheridea mülleri BOSQUET
Cytheridea hungarica ZALÁNYI
Cythereis speyeri BRADY
Cythereis fischeri M. SARS.
Hemicytheria convexa BAIRD
Hemicytheria cicatricosa REUSS
Ciamocytheridea leptostigma REUSS
Ciamocytheridea leptostigma foreolata KOLLMANN
Cyprideis punctillata BRADY
Cyprideis perangusta ZALÁNYI
Eucythere declivis MÜLLER
Miocyprideis janoscheki KOLLMANN
Haplocytheridea dacica HÉJJAS
Pontocypris declivis MÜLLER
Pontocythere perangusta ZALÁNYI
Pontocythere elongata BRADY
Loxoconcha rhombovalis POKORNY
Loxoconcha subovata MÜLLER
Cnestocythere lamellicosta TRIEBEL
Candona trapezoidea ZALÁNYI

Characteristical elements of the biofacies of the Sarmatian limestones are the *bryozoans,* which occur mostly in the littoral sediments of the Kozárdian substage. In pelitic sediments of lagoons the calcite ovoid of the species *Sphaeridia moldavica* MAC.—PAGH. (statolite after VOICU, M.) is common. The Lithothamnium are substituted by the algal genera *Lithoporella* and *Chalmasia.* In the marls, *Acicularia* are common to occur.

2. Biostratigraphic subdivision

The biostratigraphic subdivision of the Sarmatian sediments in the Tiszántúl region is based first all on the foraminiferal microbiofacies. The vertical extension of some foraminifer species is restricted to the *Kozárdian substage,* e.g. *Cibicides lobatulus* WALK.—JAC., *Elphidium reginum* D'ORB., *Elphidium josephinum* D'ORB., *Elphidium imperatrix* BRADY, *Quinqueloculina pauperata* D'ORB., *Quinqueloculina bronniana* D'ORB., *Quinqueloculina reussi* BOGD., *Triloculina inflata* D'ORB., as well as the species of the genera *Articulina* and *Dendritina* (Table 1.). The following species occur rarely, but up to now only in the sediments of the Kozárdian substage: *Triloculina scapha* D'ORB., *Quinqueloculina haidingeri* D'ORB., *Quinqueloculina fluviata* VENGL., *Quinqueloculina latelacunata* VENGL. and *Quinqueloculina karreri* REUSS. A characteristic feature of the limestone microbiofacies of littoral character of the substage is the rock-forming occurrence of Miliolina species. In the same facies, the species *Nodophthalmidium tibium* PARK.—JON. is very common.

At such places where the sediments of the Kozárdian substage develop gradually from the Upper Badenian sediments, *the oldest Sarmatian members contain also persistent stenohaline foraminifers* such as small-size *Bolivina* sp., *Borelis melo* FICHT.—MOLL., *Anomalina* sp., *Textularia* sp. This oldest microbiofacies is observable, in some cases, at the base of transgressive sequences, too. Sediments bearing stenohaline forams have been found in some boreholes of Kisújszállás, Csanádalberti, Ebes, Hajdúszoboszló and Józsa. The following ostracods have been determined by SZÉLES, M. in Kozárdian sediments: *Cytheridea punctillata* BRADY, *Cytheridea elongata* BRADY, *Cytheridea hungarica* ZALÁNYI, *Cythereis speyeri* BRADY, *Ciamocytheridea leptostigma* REUSS, *Ciamocytheridea leptostigma foreolata* KOLL., *Eucythere declivis* MÜLLER, *Miocyprideis janoscheki* KOLL., *Pontocythere perangusta* ZAL., *Pontocythere elongata* BRADY, *Loxoconcha subovata* MÜLLER and *Cnestocythere lamellicosta* TRIEBEL.

Bryozoans are common and characteristic of the limestone facies. The experience shows that their vertical extension practically does not reach beyond the Kozárdian substage.

In the sediments of the *Tinnyeian substage* the foraminifers are represented by a strongly reduced number of species of the genera *Miliolina, Nonion* and *Elphidium.* (The species number is about the half of that in the Kozárdian substage.) Common species are *Triloculina consobrina* D'ORB., *Triloculina inornata* D'ORB., *Quinqueloculina hauerina* D'ORB., *Quinqueloculina mayeriana* D'ORB., *Sinzowella novorossica* SINZ.—KARR., *Nonion depressulum* WALK.—JAC., *Nonion granosum* D'ORB., *Elphidium aculeatum* D'ORB., *Elphidium crispum* LINNE, *Elphidium hauerinum* D'ORB., *Elphidium obtusum* D'ORB. and *Rotalia beccarii* LINNE (Table 1.). The miliolina are common elements in the microbiofacies, however they do not occur any more in rockforming amount in the sediments of the Tinnyeian substage. In general, this younger substage is characterized by much simpler and poorer assemblages.

The significant elements of the ostracod fauna are the species *Cytheridea mülleri* BOSQUET, *Cythereis fischeri* M. SARS., *Hemicytheria* sp., *Pontocypris declivis* MÜLLER, *Loxoconcha rhomboidea* FISCHER, *Loxoconcha rhombovalis* POKORNY and *Candona trapezoidea* ZALÁNYI.

PALEOGEOGRAPHY

The extension of the Sarmatian formations in the Tiszántúl region did not exceed considerably the frames of the preceding Badenian sedimentary basin. Only in the southern part of the region are known sediments of the Kozárdian substage

Table 1

Species	Upper Badenian	Kozárdian substage	Tinnyean substage
Articulina sarmatica Karr.		—	
Articulina problema Bogd.		—	
Triloculina consobrina d'Orb.	—	—	—
Triloculina sarmatica Gerke		—	—
Triloculina inflata d'Orb.		—	
Triloculina bipartita d'Orb.		—	
Triloculina inornata d'Orb.	—	—	—
Triloculina scapha d'Orb.	—	—	
Quinqueloculina sarmatica Karr.		—	—
Quinqueloculina akneriana d'Orb.	—	—	—
Quinqueloculina hauerina d'Orb.		—	—
Quinqueloculina pauperata d'Orb.	—	—	
Quinqueloculina bronniana d'Orb.		—	
Quinqueloculina reussi Bogd.		—	
Quinqueloculina mayeriana d'Orb.	—	—	—
Yuinqueloculina haidingeri d'Orb.		—	
Quinqueloculina fluvita Vengl.		—	
Quinqueloculina latelacunata Vengl.		—	
Quinqueloculina karreri Reuss		—	
Massilina haidingeri d'Orb.	—	—	
Sinzowella novorossica Karr.—Sinz.		—	—
Nodophthalmidium tibium Park.—Jon.	—	—	
Nodobaculariella sp.		—	
Haplophrogmium lituus Karr.		—	
Saccamina sarmatica Vengl.		—	
Nonion depressulum Walk.—Jac.	—	—	—
Nonion granosum d'Orb.		—	—
Nonion serenus Vengl.			—

TABLE 1; Continued

Species	Upper Badenian	Kozárdian	Tinnyean
		substage	
Elphidium aculeatum D'ORB.	——	——	——
Elphidium crispum LINNE	——	——	——
Elphidium fichtelianum D'ORB.	——	——	——
Elphidium hauerinum D'ORB.	——	——	——
Elphidium antoninum D'ORB.	——	——	
Elphidium josephinum D'ORB.		——	
Elphidium listeri D'ORB.		——	——
Elphidium obtusum D'ORB.	——	——	——
Elphidium rugosom D'ORB.		——	——
Elphidium reginum D'ORB.		——	
Elphidium imperatrix BRADY		——	
Elphidium macellum D'ORB.		——	——
Elphidium incertum WIEL.		——	
Elphidium striatopunctatum FICHT.—MOLL.		——	
Dendritina arbuscula D'ORB.		——	
Dendritina elagans D'ORB.	——	——	
Dendritina juleana D'ORB.		——	——
Cibicides lobatulus WALK.—JAC.	——	——	
Rotalia beccarii LINNE	——	——	——
Borelis melo FICHT.—MOLL	——	—	
Discorbis obtusus D'ORB.	——	—	
Discorbis vilardeboana D'ORB.	——	—	
Bolivina dilatata REUSS	——	—	

to overlie transgressively more ancient rocks. Relying upon presentday evidence one can state that the Badenian sedimentary basin was added several island during the Sarmatian age. The measure of overflooding was not uniform within the Sarmatian time interval, as testified to by the Tinnyeian transgressive beds of the boreholes at Furta—Zsáka. Unfortunately, the erosion period that followed the Sarmatian makes impossible the more exact reconstruction of paleogeography.

The formations of *the Kozárdian substage* have been hit upon in the most part of the Tiszántúl area. In the southern sector of the Tiszántúl, several details of the ancient shore-line could be reliably reconstructed on the base of transgressive sequences *(Fig. 3)*. The exploration of the deep Neogene depressions in the southern part of the Great Plain did not promote the knowledge of the Upper Miocene formations, but we have good reasons for assuming that those areas also belonged to the Sarmatian sedimentary basin. In the central and southern part of the Tiszántúl one can deduce a very unquiet shoreline, a series of islands, and generally shallow water (as proved by the mostly littoral sediments). Only in the depression situated between Nagyvárad (Oradea) and Szatmárnémeti (Satu Mare) filled up with chiefly detrital sediments may have existed a deeper partial basin open towards the high sea. In the Northern Tiszántúl during the time range of the Kozárdian an accumulation of rhyolitic and rhyodacitic tuffs was going on. Early Sarmatian brackish water sediment are of rather restricted extension in this area.

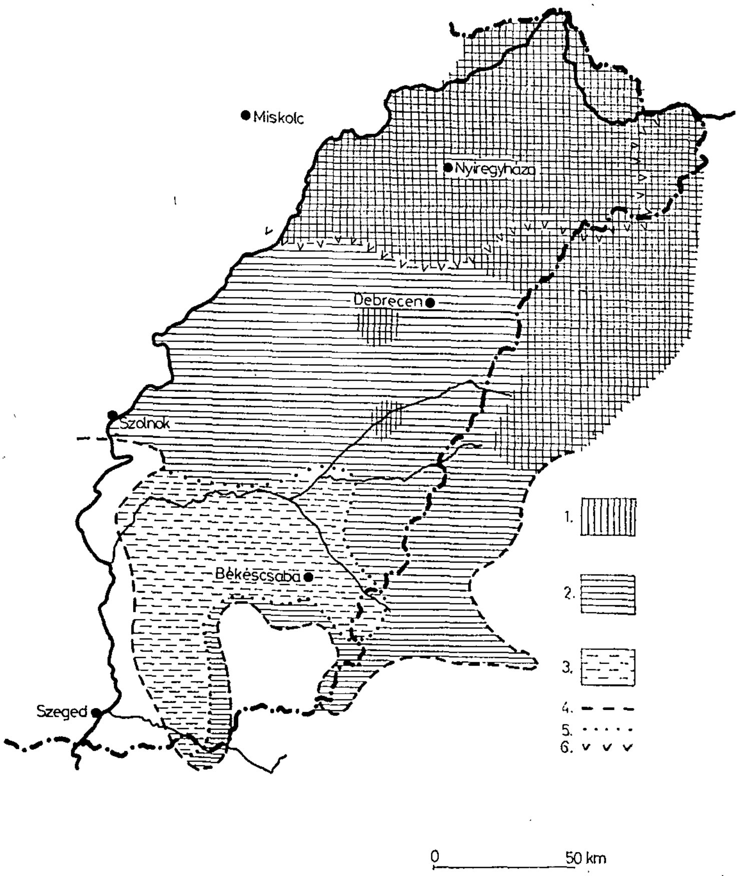

Fig. 3. Sketch of the extension of Sarmatian formations in the Tiszántúl region

Legend

1. Formations of the Tinnyeian substage
2. Formations of the Kozárdian substage
3. Hypothetic extension of hitherto not explored Sarmatian
4. Shoreline (established)
5. Extension contours of the hypothetic Sarmatian sediments
6. Contours of extension of the continental volcanogenic formations (mostly of the Kozárdian substage

The present-day distribution of the formations of *the Tinnyeian substage* provide poor information concerning the original paleogeographic setting. The actually isolated occurrences must have been came into being in a much larger sedimentary basin.

The truncated Tinnyean sequences and the biostratigraphically proved gradually transgressive nature of Lower Pannonian formation one has to count with a *denudation on the greatest part of Tiszántúl (with the exception of the deep depressions) at the Late Miocene Early Pannonian boundary.* The late Sarmatian sediments develop, at least at some places, gradually from the early Sarmatian beds (at Hajdúszoboszló), at other places they are transgressive (at Furta—Zsáka, Nyírlugos, Nyíregyháza, Tisztaberek). It is very likely that at the beginning of the Tinnyeian age further paleogeographic changes occurred in the sedimentary basin. In some areas the sedimentation was going on, others became emergent land, and at several places the transgression proceeded. The increased percentage of detrital-clastic sediments relates to the intensification of material supply. Most probably the increase in freshwater supply and the starting isolation of the partial basins combined produced the changes observable in the microfaunal assemblages. The water of the late Sarmatian sedimentary basin gradually lost salinity. Purely freshwater sediments are not known in the Tiszántúl region; eventually the clastic, faunistically sterile sediments of the Nagyvárad (Oradea) partial basin may represent the terminal portion of the stage.

The area of accumulation of continental tuffs became restricted in comparison to the Kozárdian substage, but the volcanic activity has not ceased yet. In the Tinnylean sequences of the Northern Tiszántúl the considerable amount of tuffites and tuffs proves the continuation of volcanic activity.

The Sarmatian sedimentary basin of the Tiszántúl region was delimited towards the North-West, more or less along the line to be drawn along the Tisza River from Szolnok to Tiszafüred, by a ridge consisting of acidic volcanites mostly of Badenian age. Towards the West, a continental made up mostly by crystalline rocks can be contoured. At the margin of the ridge in the Danube-Tisza interfluve numerous boreholes disclosed formations of the Kozárdian substage, supporting, by their transgressive position, the presence of the shoreline in that area.

The connexion with the Sarmatian sedimentary basin known to have existed in the Danube-Tisza interfluve can be proved by means of the boreholes drilled in the area of Szolnok and Szandaszőlős.

Connections to the northern part of Hungarian Plain can be traced at hand of the Sarmatian formations known from the boreholes of Hajdúnánás and Balmazújváros. One may assume that several connexions may have existed during some restricted intervals within the Sarmatian between the Tiszántúl region and the neighbouring areas.

In the territory of the Hungarian Plain beside the Sarmatian sedimentary basin of the Tiszántúl region *three* Late Miocene basin parts can be distinguished on the basis of hydrocarbon drilling. In the central and southern parts of the *Danube-Tisza interfluve* the facies and the stratigraphic setting are identical with those of the Tiszántúl.

In the vicinity of Gödöllő, Tura, Jászberény and Farmos there is a small-size partial basin filled up by Kozárdian and Tinnyeian brackish water sediments and subordinately by continental tuffs. This may have been directly and uninterruptedly connected with the sedimentary basin of the *Northern Hungarian Plain*, which is paralell with the present-day margin of the basin. These varying Sarmatian formations can be correlated without any difficulty with the Sarmatian of the Northern Central Mountains.

The Sarmatian sediments of the Tiszántúl region can be correlated biostratigraphically, relying upon identities of the microfaunal assemblages, with those of the surrounding basin areas.

The tripartite Sarmatian known in the Neogene depression of *Soviet Transcarpathia* has microfaunal assemblages which permit a fairly good correlation nothwithstanding the very different lithostratigraphy [Pishvanova, L.—Tkatshenko, O. F., 1971, Gurzhiy, D. V.—Venglinskiy, I. V., 1970, Boda, J., 1974, Sviridenko, V. G., 1976]. The *Dorogobrativska Zone* corresponds in Hungary to the oldest beds containing persistent marine foraminifers. This and the *Lukivska Zone* combined fill out the time range of the Kozárdian. The *Almaska Zone*, according to its microfauna, is the equivalent of the Tinnyean substage. It may be some-what more complete than the Tinnyean in the Hungarian Plain. These two units may be considered more or less equivalent.

The Sarmatian formations of the *East-Slovakian Basin* known in the neighbouring areas to the Hungarian Plain, as based upon data published by Svagrovsky, J. [1971] are fairly well correlable, at least as concerns the older member. Accordingly, the Kozárdian substage comprises the *Olšava* and *Myšl'a* beds. The correlation of the "*tufaceous-lignitic series*" and the Tinnyean substage is much more problematic at present.

Relying upon the investigation of the Sarmatian formations disclosed by hydrocarbon exploratory drilling in the Tiszántúl region the authors think to have successfully proved also for this region the bipartite nature of the Sarmatian in Hungary as well as the presence of one part of the Bessarabian substage of Eastern Europe in the Upper Miocene of Hungary.

Table 2

<table>
<tr><th colspan="2">Vienna Basin</th><th>Hungarian Great Plain</th><th>East Slovakian Lowland</th><th>Transcarpathian Depression</th><th colspan="3">Ponto-Euxin Basin</th></tr>
<tr><td colspan="5" rowspan="3">Pannonian stage
(Pannon s. s., „Meotian", Lower Pannon)</td><td>Kherson horizon</td><td rowspan="2">Khersonian</td><td rowspan="2">Upper Sarmatian</td></tr>
<tr><td>Rostow horizon</td></tr>
<tr><td>Bessarab horizon</td><td rowspan="2">Bessarabian</td><td rowspan="2">Middle Sarmatian</td></tr>
<tr><td rowspan="3">Sarmatian</td><td>Mactra Beds
Ervilia Beds</td><td>Tinnyean substage</td><td>Serie with tuffs – lignites</td><td>Almaska horizon</td><td>Bauren horizon</td></tr>
<tr><td rowspan="2">Rissoa Beds</td><td rowspan="2">Kozardian substage</td><td>Myšl'a Beds</td><td>Lukowo horizon</td><td>Volhyn horizon</td><td rowspan="2">Volhynian</td><td rowspan="2">Lower Sarmatian</td></tr>
<tr><td>Olšava Beds</td><td>Dorogobrativska horizon</td><td>Kuyor horizon</td></tr>
<tr><td colspan="4">Upper Badenian</td><td>Bashevsk horizon</td><td colspan="3">Vesselyanka Beds</td></tr>
</table>

The attempt made on stratigraphic correlation, utilizing the data published in the papers listed in the references, is presented in Table 2. Notwithstanding the great number of borehole data, no reasonable suggestion can be made as to the time correlation of the Early Pannonian sediments of Hungary with the Late- and partly Middle Sarmatian of Southeastern-Europe.

REFERENCES

BODA, J. [1959]: A magyarországi szarmata emelet és gerinctelen faunája. (The Sartamian Stage in Hungary and its Invertebrate Fauna.) — MÁFI Évkönyv *47*, p. 569—862.

BODA, J. [1971]: A magyarországi szarmata emelet tagolása a gerinctelen fauna alapján. (The Subdivision of Sarmatian is Hungary based on the Invertebrate Fauna.) — Földt. Közl., *101*, p. 107—113.

BODA, J. [1974]: A magyarországi szarmata emelet rétegtana. (Stratigraphy of the Sarmatian in Hungary.) — Földt. Közl., *104*, p. 249—260.

GURZHIY, D. V. — VENGLINSKIY, I. V. [1971]: Facii neogena Predkarpatskogo i Zakarpatskogo progibov. — Acta Geol. Acad. Sci. Hung., *14*, p. 393—405.

ISTOCESCU, D. — IONESCU, G. [1968]: Geologia parţii de nord a Depresiunii Panonice (sectorul Oradea-Satu Mare.) — Dari de seăma ale sedintelor *55*, p. 73—87.

JÁMBOR, Á. [1971]: A magyarországi szarmata. (The Sarmatian in Hungary.) — Földt. Közl., *101*, p. 103—106.

KOJUMDGIEWA, E. [1971]: Gliederung und Korrelation der Sarmatbildungen in der Becken des Paratethys. — Földt. Közl., *101*, p. 209—216.

K. LAKY, I. [1966]: A magyarországi szarmata foraminiferák. (Sarmatian Foraminifera in Hungary.) — MÁFI Évi jel. 1964. évről, p. 475—493.

KŐRÖSSY, L. [1956]: A Tiszántúl északi részén végzett kőolajkutatás eredményei. (Results of hydrocarbon prospecting in the northern part of the Tiszántúl region.) — Földt. Közl., *86*, p. 390—402.

KŐRÖSSY, L. [1971]: Mélyföldtani és fejlődéstörténeti vázlatok a magyarországi pannonból. — In: A magyarországi pannonkori képződmények kutatásai. (Sketches on Subsurface Geology and Evolution of the Pannonian in Hungary. — In: Studies on the Pannonian Formations in Hungary.) — Akadémiai kiadó, Budapest.

KŐVÁRY, J. [1965]: A magyarországi szarmata üledékek Foraminifera vizsgálata (Investigation in the Foraminifera of the Sarmatian in Hungary.) — *Manuscript.*

KŐVÁRY, J. [1973]: Szénhidrogénkutató fúrások által a Kelet- és Délkelet-Tiszántúlon feltárt neogén tengeri üledékek mikrobiofácies vizsgálata. ((Investigations into the Microbiofacies of Neogene Marine Sediments Disclosed by Hydrocarbon Exploratory Boreholes in the Eastern and Southeastern Parts of the Tiszántúl region.) — *Manuscript.*

KRETZOI, M. [1961]: A diósdi gerinces fauna és a miocén-pliocén határ kérdése. (The Vertebrate Fauna from Diósd and the Problem of the Miocene (Pliocene Boundary.) — Földt. Közl., *91*, p. 208—214.

MOTAS, J. — MARINESCU, FL. [1971]: L'evolution et subdivisions du Sarmatien dans le Bassin dacique. — Földt. Közl., *101*, p. 240—243.

PANTÓ, G. [1965]: Miozän Tuffhorizonte Ungarns. — Acta Geol. Acad. Sci. Hung., *9*, p. 225—233.

PISHVANOVA, L. — TKATCHENKO, O. F. [1971]: Paleogeograficheskie karty miocena zapadnyh oblastei USSR. — Földt. Közl., *101*, p. 265—276.

SCHMIDT, E. R. [1939]: A kincstár csonkamagyarországi szénhidrogénkutató mélyfúrásai. (Hydrocarbon drilling done by the State Treasury in Post-World-War I. in Hungary.) — Földt. Intézet Évkönyve *34*, p. 267.

SCHRÉTER, Z. [1941]: A Kárpátok által körülvett medencék szarmáciai képződményei és azok állatvilága. (The Sarmatian Formations of the Basins Enclosed by the Carpathians and their Fauna.) — Mat. Term. tud. Ért., *60*, p. 243—294.

SVAGROVSKY, J. [1971]: Die Bedeutung des Studiums der Mollusken für die Bestimmung der Biostratigraphie der sarmatischen Sedimente der Tschechoslowakei. — Földt. Közl., *101*, p. 307—311.

SZEPESHÁZY, K. [1971]: A Tiszántúl középső részének miocén képződményei a szénhidrogénkutató mélyfúrások adatai alapján. (The Miocene Formations in the Central Part of the Tiszántúl as Revealed by Hydrocarbon Drilling.) — MÁFI Évi jelentése 1968. évről, p. 297—326.

SZÉLES, M. [1958]: A magyarországi szarmata üledékek Ostracoda vizsgálata. (Investigation on the Ostracods of the Sarmatian Sediments in Hungary.) — *Manuscript.*

SZÉLES, M. [1970]: A felsőmiocén (szarmata) képződmények rétegtani értelmezése az alföldi szénhidrogénkatutó fúrások alapján. (Stratigraphic Interpretation of the Upper Miocene (Sarmatian) Formations Based on Hydrocarbon Drilling Evidence in the Hungarian Plain.) — Földt. Közl., *100*, p. 132—143.
SVIRIDENKO. V. G. [1976]: A kárpátaljai süllyedék és aljzatának földtani felépítése és szénhidrogénföldtana. (Geological Setting and Hydrocarbon Geology of the Transcarpathian Depression and its Basement.) — Földt. Közl., *106*, p. 464—475.
VÖLGYI, L. [1959]: A nagyalföldi kőolajkutatás újabb eredményei. (New Results of Oil Prospecting in the Hungarian Plain.) — Földt. Közl., *89*, p. 37—52.
VÖLGYI, L. [1965]: A Nagyalföld középső részének mélyföldtani vizsgálata. (Investigation to the Subsurface Geology of the Hungarian Great Palin.) — Földt. Közl., *95*, p. 140—163.

Manuscript received, May 30, 1978

DR. KÁROLY SZENTGYÖRGYI
Research Laboratory for
Oil and Gas Industry
H-5000 Szolnok
Munkásőr u. 43.
Hungary